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ABSTRACT

The learning effects of display motion in procedural learning tasks were examined in two studies. In the first study, two videotapes with identical sound tracks were constructed--one using the recorded television camera motion, the other substituting a parallel series of still camera shots. The results showed a superiority of the motion condition. The second study was designed to test the hypothesis that motion functions so as to cue the critical elements of the display. Cuing arrows were added to the videotapes to show the direction of motion. The results again showed the superiority of the motion condition. No effect was attributable to the cuing arrows, and no interaction was observed. For the motion conditions, significantly less time was required to perform the task in both trials. (Author/JY)

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The film medium of procedural learning has been examined by many researchers. Many of the early research studies are contained in Lumsdaine (1961). Motion, as a variable, has received less attention in these studies, being represented only by Gagné's (1961) significant contribution. Gagné (1961), using three different hour type tests, showed that motion facilitated performance, as indicated by the number of correct items which were tied in the various experimental conditions. Lange (1954), however, did not find motion as a significant factor in learning to disassemble, repair, and reassemble a sub-assembly, a task involving twenty-two discrete sub-operations.

Using the overhead projector, Silverman (1958) found that students who learned with the aid of manually-operated animated transparencies could better load and dry fire three different weapons than those who learned with the aid of static transparencies. He specifically related an increased effectiveness, due to motion when more than one part of the display is in motion at the same time. Most recently, Allen and Waterbeck (1968), comparing motion sequences with two different still sequences for fact recall, serial ordering, and concept learning tasks in three different subject areas concluded that serial ordering of the content seemed to be most susceptible to influence by the motion picture mode.

STUDY I

The first study was designed to authenticate, in a previously unstudied task, (disassembling a weapon) the importance of display motion in procedure learning. The design was intended to clarify the locus of

an anticipated action effect. Following an overview of the entire disassembly, the removal of each of the sub-units was cued by a short demonstration. After the learner completed the entire task, he was required to perform the entire disassembly, without cues, to show if the conditions enabled differential recall of the order of the sub-units of the disassembly task.

METHOD

The 40 male subjects were Army enlisted personnel in their sixth week of basic training. The subjects were selected by their unit first assignment in groups of eight or twelve to fulfill a consistency requirement for personnel. On arrival, the subjects were divided by random assignment between the experimental conditions (which were presented in a pre-determined random sequence).

Two conditions were created to compare a motion sequence with a still sequence. An on-the-shelf videotape, used to teach turret mechanics the disassembly of an M60 machine gun, was selected to provide the motion sequences. In the first condition the videotape was re-edited to consist of (1) general orientation and nomenclature of the weapon, (2) an overview of the entire disassembly, and (3) a step-by-step repetition of the nine discrete sub-units, each followed by two segments of time: learner performance opportunity time (with a still picture of the completed operation on the screen) and black screen time to permit the experimenter to perform the operation in the event the learner was unable to perform it. In the second condition a set of still sequences was used to replace the second and third parts of the

re-edited videotape. Using the identical sound track, this set of still photograph sequences was placed on videotape for showing the disassembly phases of the demonstration. These still shots were selected to provide the maximum assistance to the learner, rather than to imitate the motion sequence camera angles.

Each subject was placed at a table, the rear of which was 36" from a 24" television screen. On each table an M3 machine gun was placed so that the configuration would match the one as shown on the TV screen. Each subject was assigned an experimenter who provided the initial instructions, recorded the time it took the subject to perform each of the disassembly operations, and performed a specific sub-operation for the subject if he was unable to perform it, prior to the next videotaped segment. On completion of the disassembly of the first weapon, the TV was turned off and the subject was immediately taken to a second table on which was placed an identical weapon and instructed to disassemble this weapon. The times for each of the sub-operations were again recorded and if the maximum time was exceeded, the experimenter performed the proper operation for the subject. Prior to this experiment, the weapon was unfamiliar to all subjects.

RESULTS

The data was analyzed, using an analysis of variance for unequal groups, since scores of three of the subjects were omitted due to procedural error.

The mean times for each sub-operation and the F ratio are recorded in Table 1. A superiority of the motion condition is shown by the

Sub-Operations Removed at:	Trial No.	Motion Sequence Mean Time (Seconds)	Skill Sequence Mean Time (Seconds)	F Ratio	Variance accounted for ω^2
Removal	1.	11.824	9.333	1.13	----
	2.	6.941	8.556	0.71	----
Back Plate	1.	14.706	23.389	21.32**	0.35
	2.	10.412	19.139	6.35*	0.13
Main Bolts	1.	7.353	11.611	6.91*	0.14
	2.	8.647	8.500	0.08	----
Front End Plates	1.	22.389	23.389	0.48	----
	2.	23.647	23.833	0.18	----
Power	1.	13.059	14.833	1.57	----
	2.	14.529	18.361	3.74	----
Main	1.	13.941	16.139	1.29	----
	2.	10.617	16.000	6.71*	0.19
Thermo	1.	7.706	19.833	21.18**	0.35
	2.	13.706	16.361	2.61	----
Screws and Front Caps	1.	42.294	67.722	13.61**	0.31
	2.	31.333	67.389	6.94*	0.19
Accelerator	1.	10.059	14.944	3.37	0.06
	2.	9.529	9.361	0.47	----
Total Time	1.	168.353	204.389	16.79**	0.27
	2.	130.647	169.694	6.74*	0.09

* $p < .05$
** $p < .01$

Table 1

Mean Time, F Ratio and Variance Accounted For Between Skill and Motion Sequences For Disassembly of the M61 Machine Gun

results. For the first total (card), significantly less time was required to perform the total task and four of the nine sub-operations. The number of sub-operation sequencing errors on the second total did not differ between conditions. Since the experimenter demonstrated the correct operation when the subject failed to perform it on trial one, the times for the second trial are partially confounded, and therefore, cannot be interpreted as representing the difference between experimental conditions.

STUDY II

The first study clearly showed a learning effect attributable to the motion of the learning display. The motion effect did not appear for all sub-operations. The second study was designed to test the hypothesis that motion functions so as to cue the critical elements of the display. Therefore, cuing was provided in an alternative way in the second study.

METHOD

The 80 male subjects were Army enlisted personnel in their sixth week of basic training. The subjects were selected by their unit first assigned to fulfill a requirement to provide personnel. On arrival, the subjects were divided by random assignment among the experimental conditions (which were presented in a pre-determined random sequence).

Condition A was the videotape used in the first study to represent the motion condition. Condition B was the identical sound and video

according of Condition A with the addition of white noise screen intended to emphasize the critical nature of the various sub-operations.

Condition C was a slightly modified version of the videotape presenting the still sequences in the first study. The original sequences, which were shown in finely cut as before, were reshot and revised so as to provide the best possible sequences of still shots. Condition D was the identical sound and video recording of Condition C with the addition of white noise screen intended to indicate the critical sections of the various sub-operations.

Each subject was placed at a table, the rear of which was 36" from a 24" television screen. On each table an M3 machine gun was placed with the barrel pointing to the subject's left. Each subject was assigned an experimenter who provided the initial instructions, recorded the time it took the subject to perform each of the disassembly operations, and performed a specific sub-operation for the subject if he was unable to perform it, prior to the next videotaped segment. On completion of the disassembly of the first weapon, the TV was turned off and the subject was immediately taken to a second table on which was placed an identical weapon and instructed to disassemble this weapon. The times for each of the sub-operations were again recorded and if the maximum time was exceeded, the experimenter performed the proper operation for the subject. Prior to this experiment, the weapon was unfamiliar to all subjects.

RESULTS

The data was analyzed, using a 2 x 2 analysis of variance. Scores

of four subjects were omitted on the first trial due to a procedural error and the necessary balancing.

The mean time for each sub-operation on each of the four conditions and the F ratios are recorded in Table 1. The results of the analysis of variance indicate a superiority of the action condition, an effect attributable to using screws, and no interaction. For the action conditions, significantly less total time was required to perform the total task on the first trial. Of the four omitted sequences (those which showed a significant difference in the first study), only one showed the action condition as superior in the second study. However, three other sequences showed the action sequence superior, and one showed the still sequence as superior.

Analysis of the sub-operations seems an effective way to determine factors which may be involved in lowering the weapon disassembly.

Barrel. The removal of the barrel showed the superiority of a still sequence over the action sequence. It is notable that many subjects had difficulty with the latch lock and the depressing of the latch in the action condition. An examination of the action sequence display suggests that the explicit cue to press the latch was not provided (save by inference). The action sequence did not clearly provide the information required to perform the task. Back plate. The still sequence did not provide as good an orientation to perform the sub-operation as did the action sequence. Only seven subjects from the action sequences were noted as having difficulty in locating the latch and latch lock, while twenty subjects in the still sequences were noticed as having difficulty locating the latch and latch lock. These

Table 1.

Mean Times, F Ratios and Variances Accounted For Between Shift and Within Sequences For Discriminability of the ERP Matrices Use

Sub-Ejected Cue Reserved, p(E)	Default	Within Sequence Mean Time (Seconds)	Within & across Sequence Mean Time (Seconds)	Shift Sequence Mean Time (Seconds)	Shift & across Sequence Mean Time (Seconds)	across Effect F Ratio	Within Effect F Ratio	Variance Accounted For ω^2	Interaction F Ratio
	S:	10.7789	10.7205	10.7178	8.7154	0.10	10.11789	0.13	0.18
Reserve									
	S:	8.8889	8.778	8.8886	8.8711	0.11	0.7749	0.01	0.10
	S:	17.7137	10.3848	10.1258	10.1258	0.12	0.307288	0.14	0.01
Reach Plane									
	S:	10.8894	10.8333	11.3333	10.8867	0.08	2.89	0.01	0.13
	S:	10.8333	10.8211	10.7137	10.1258	0.08	0.01	------	0.17
Main Outline									
	S:	11.7222	11.7556	10.7778	11.8867	1.07	1.13	------	0.01
	S:	10.3942	10.3778	10.1258	10.1258	0.76	1.03	------	0.75
Reach & Objectives									
	S:	10.7556	11.1667	10.8333	10.8111	0.01	0.01	------	1.03
	S:	10.7611	11.3889	10.7137	11.3942	1.04	10.11789	0.13	0.18
Shown									
	S:	11.7222	11.7889	10.8556	10.1667	0.01	1.13	0.01	0.15
	S:	10.3889	10.2133	10.1611	10.1258	0.03	0.01789	0.17	0.01
Main									
	S:	11.1111	8.7889	11.3556	11.8867	0.07	11.11789	0.19	0.13
	S:	8.7611	8.8667	11.1111	10.1258	0.13	10.12789	0.17	0.13
Reach Changes									
	S:	8.8111	7.8889	11.1111	11.1111	0.05	0.78789	0.19	1.07
	S:	10.3947	10.7258	11.1111	10.1678	0.11	0.817	0.11	0.13
Reach Troop									
	S:	10.8944	10.7222	10.7778	10.7222	0.18	1.05	------	1.05
	S:	10.7258	8.8942	11.1111	10.8.13	0.11	0.1.13	0.11	0.11
Accelerations									
	S:	8.8111	8.7722	11.8333	11.8867	0.18	0.11789	0.19	0.19
	S:	1778.7137	1277.8778	1258.1258	1257.1778	0.103	0.78.8	0.101	0.13
Total Time									
	S:	138.811	141.1111	141.1111	143.1111	0.14	0.11789	0.11	0.17

$^{a}p < .05$
$^{b}p < .01$

critical parts are under the weapon so that it must either be tipped or moved so that the latch and latch lock are over the edge of the table. [There were no verbal cues in the sound track, although the weapon was always so tipped in the still conditions and over the edge of the table in the motion conditions. The original still sequence showed the weapon over the edge of the table, but in the first study the subjects did not appear to use this information.] Safe buffer. Both sequences seemed equivalent, following revisions of the still sequence, as comments on high scorers only indicated slowness in all conditions. Hand and elevator. Both sequences seemed equivalent. Jaws. The motion sequence was slightly superior, as only two subjects had difficulty locating the door detent release hole, while twelve, who saw the still sequence, had difficulty in locating the hole and two others failed to pull the door when released. Suit. The superiority of the motion sequence appears to be traceable to a greater slowness in separating the two pieces by the group exposed to the still sequence. Charges. The time for removal of the charges, following revision and additional cuing, indicated a superiority of the motion sequence. Two kinds of mistakes were identified with the still sequence; subjects attempted to unscrew the detent knob and subjects failed to move charges forward when the dent knob was released. Food tray. Two sorts of errors may have balanced to provide the seemingly equivalent performances of the still and motion groups. Five subjects in the motion sequence forgot to remove the food tray (versus one of the subjects who saw the still sequence). However, six sub-

jects were noted as failing to release the cover pin tension in the still sequences, while only one notation for this error was made concerning subjects in the motion sequences. Accelerator. The motion sequence seemed to provide a better cue as to the level of effort required to pull out the accelerator. Only three subjects were noted as not pulling hard enough in the motion sequence, while seven subjects in the still sequence provide this notation.

DISCUSSION

The results of these two experiments do not provide evidence to suggest a single explanatory principle for the apparent superiority of a motion display over a static display in the learning of a perceptual task. It does not appear that motion functions so as to focus the learner's attention upon critical elements of the display, since the use of cuing arrows provided neither a main effect nor an interaction. The performance improvement, following redesign of the still sequences which were shown as inferior to the motion sequences in the first study, suggests the possibility that the pretesting and redesign of still sequences can provide equivalent learning to some motion sequences. That is, the difference between the sequences cannot be attributable to motion as such, although it seems quite probable that not as much pretesting and revision may be required for motion sequences to reach an optimal level.

Two of the motion sequences and three of the still sequences failed to show explicitly the information that some learners need to orient themselves or to perform the sub-operation. These flaws probably could

be remedied by revisions of the sequences.

One still sequence, for some learners, failed to use an adequately the level of effort required to perform the sub-operation. The motion sequence, therefore, in some instances can provide a cuing of effort level which is not possible with a still sequence. However, verbal cues on the sound track might provide equivalent performance on the still sequence.

Three instances of the superiority of the motion sequences over the still sequences remain. Simultaneous motion in different directions by the learner was involved in these sub-operations. The case had to be pulled as the detent was disengaged, the charger had to be pulled forward as the spring-loaded detent knob was pulled, and the accelerator had to be slightly raised as the feed tray cover was lowered to release the tension on the cover pin. These results tend to agree with Silverman's (1958) conclusion that the differences between still and moving displays can be related to the factor of simultaneously moving parts. The present studies did not, however, explicitly test for this factor.

Simultaneous motion may not be the explanatory factor involved in the superiority of motion sequences over still sequences. The still sequence concerning the charger provided explicit verbal and pictorial cues to lift the knurled head of the detent knob. Some learners who saw the still sequence erroneously attempted to unscrew this knob (which does resemble the knurled head of a thumb-screw). It is possible to assume that the learner is asked to perform an unfamiliar action (i.e., lifting) on an object which has previously been associ-

ated with a rotating action (i.e., unscrewing). The continuous climate changes depicted in the motion sequence appear to have provided a different internalization of what the learner perceived that he was to perform than did the still sequence, for at least some learners.

For operations involving simple readily codable motion actions there seems little difference whether or not display motion is present. Erroneous verbal cues were included for one sub-operation in these studies. The script on the sound track stated, "Now, lift up firmly on the accelerator and close the cover." The pictorial cues in both motion and still sequences showed that the cover had to be lowered to nearly 45° before the accelerator could be raised. In this example, extreme spatial bonding than exists for the motion sequence, but several learners exposed to the still sequences erroneously attempted to follow the verbal instructions as stated.

It appears that Bartlett's (1954) hand tying task consists of actions not overly familiar or highly codable into words. Allen and Waterhouse (1968) seemed to find a motion effect in serial ordering recall when the events were unfamiliar or not readily codable into words. Further studies to explore the relationship of the factors of unfamiliar movements and verbal codable movements with moving and still sequences are suggested by these studies, as well as the factor of simultaneous movement. The role of individual learner differences should also be examined.

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